Lab tests on applicability of S-wave-based and CPT-based liquefaction evaluations

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In the present liquefaction evaluation using penetration resistance, the aging effect may not be properly evaluated because the penetration process is too destructive to discern delicate soil fabric developed during aging. In contrast, shear-wave velocity ($V_s$) is considered to be promising that may be able to differentiate subtle changes in soil fabric affecting CRR because of its non-destructive nature.

In this research, bender-element triaxial tests are carried out to investigate the $CRR-V_s$ relationship for two kinds of reconstituted sands with variable relative densities $D_r$ and fines contents $F_c$. Then, accelerated tests adding a small amount of cement to fines-containing sands are conducted to examine the cementation effect on the $R_L-V_s$ relationship. Furthermore, intact samples recovered from in situ sand deposits at several places are also tested and compared with reconstituted sands from the same samples to examine the aging effect on the liquefaction resistance of in situ soils.

Major findings are as follows:

1) A $R_L-V_s$ relationship of reconstituted sands may be approximated by a single unique curve despite the differences in $D_r$ or $F_c$ for the same sand.

2) However, the curve is different for different sands, indicating that the $R_L-V_s$ relationship is sand-dependent and not applicable to sands in general.

3) In the $R_L-V_s$ relationship of reconstituted sands, while $R_L$ increases by 100% from 0.1 to 0.2 for instance, $V_s$ increases only by 17~25%, indicating that $V_s$ measurement has to be precise enough to be able to make reliable $R_L$-estimation in situ.

4) Specimens with artificial aging effect by adding small amount of cements tend to have higher $R_L$ and $V_s$, making different $R_L-V_s$ relationships reflecting the artificial cementation.

5) Intact specimens from in situ have higher $R_L$ and $V_s$ than those reconstituted from the same specimens, presumably reflecting the aging effect. The differences in $R_L$ and $V_s$ depend not only on geological ages but also strongly on fines content $F_c$ and its plasticity.

6) $R_L-V_s$ relationships of natural intact soils considering the aging effect seem to be quite different from site to site and also different from artificially cemented sands. It is also different from previously proposed curves by other researchers. However, a common trend can be observed that the increment in $R_L$ for the same $V_s$-increment becomes larger with increasing $F_c$.

7) The same two kinds of sands are tested also in a mini-cone triaxial test apparatus (Kokusho et al. 2011) to investigate $R_L-q_t$ relationship. Comparison of the two test results reveals that $R_L-q_t$ relationship is almost uniquely applicable even to different sands, though it may not be able to detect subtle effect of soil fabrics.